Determination of Layer Coefficients for New HMA Materials

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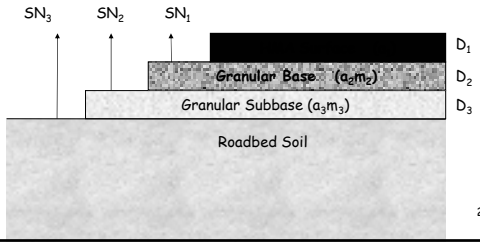
1

Background

- Structural coefficients central to current flexible pavement design

$$SN = a_1D_1+a_2m_2D_2+\ldots+a_nm_nD_n$$



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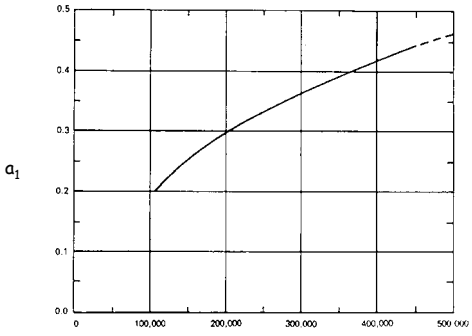
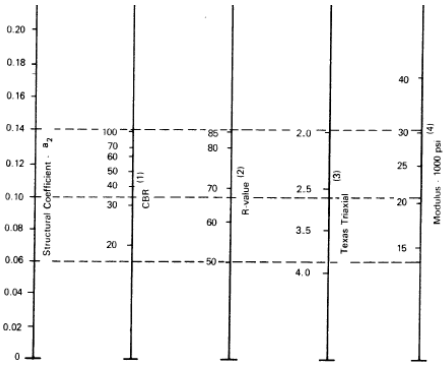
Structural Coefficients



3

Structural Coefficients



Granular Base Chart (1993 AASHTO Guide)

4

Drainage Coefficients

- Depends on quality of drainage and availability of moisture

m_i Values for Modifying Structural Layer Coefficients (Untreated Base and Subbase Materials)

		% Time Saturated			
Quality	Water Removed	< 1%	1 -5 %	5 - 25%	> 25%
Excellent	2 hours	1.40 - 1.35	1.35 - 1.30	1.30 - 1.20	1.20
Good	1 day	1.35 - 1.25	1.25 - 1.15	1.15 - 1.00	1.00
Fair	1 week	1.25 - 1.15	1.15 - 1.05	1.05 - 0.80	0.80
Poor	1 month	1.15 - 1.05	1.05 - 0.80	0.80 - 0.60	0.60
Very Poor	Never Drain	1.05 - 0.95	0.95 - 0.75	0.75 - 0.40	0.40

5

Problem Statement

- Structural Coefficients based on AASHO Road Test
- Typically not revised/improved
  - ALDOT
    - a = 0.44 HMA Surface
    - a = 0.30 asphalt treated base layer
- Many new mixes
  - Superpave
  - OGFCs
  - SMAs
  - Polymer modification
- Need to update/revise/improve coefficients

6

Key Question

- Can we distinguish mixtures by structural coefficients?

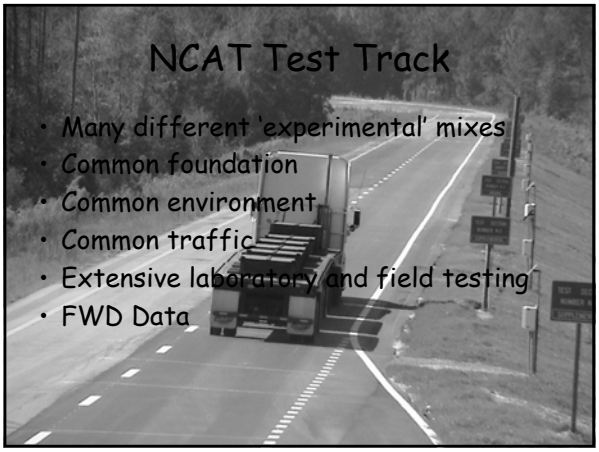
7

Scope

- NCAT Test Track
  - 46 mixes
    - 26 on tangent section
- Deflection Data
  - Estimate structural number
    - Derive structural coefficients

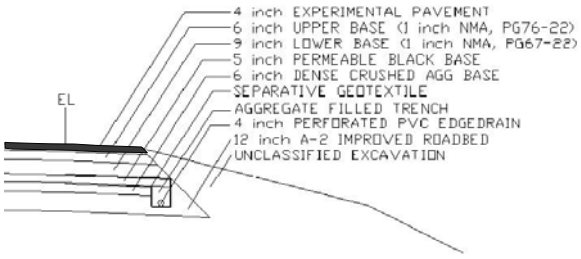
8

NCAT Test Track



- Many different 'experimental' mixes
- Common foundation
- Common environment
- Common traffic
- Extensive laboratory and field testing
- FWD Data

Structural Buildup at Track



10

Methodology

- Utilize AASHTO 2-layer backcalculation
  - Estimate SN_{eff}
- Determine a_i relative to a reference section
  - S7
    - Superpave
    - PG 67-22 (6.66% Asphalt Content)
    - Unmodified
    - Gradation below the restricted zone
- Look for trends and explanatory variables

11

FWD Testing

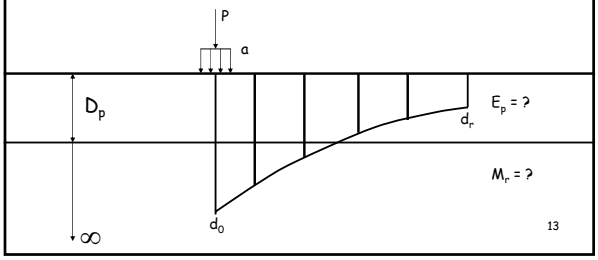
- Conducted by ALDOT
- Outside wheelpath
- 2 stations / section
- 2 to 3 drops / station
- Approx. 9 kip load

Testing Dates
Jan. 22, 2001
Jan. 29, 2001
Feb. 26, 2001
Mar. 26, 2001
May 7, 2001
June 11, 2001
Aug. 27, 2001

12

AASHTO Backcalculation

- Section L5.3 of 1993 AASHTO Guide
- 'Two-layer' approach



13

M_r Calculation

- Boussinesq Theory

$$M_r = \frac{0.24P}{d_r \cdot r}$$

- typically radius at sensor 7
- Not temperature dependent

14

Ep Calculation

- Use center deflection
- Need to temperature correct d_o
- Solve for E_p numerically

$$d_0 = 1.5qa\left[\frac{1}{M_r\sqrt{1+\left(\frac{D}{a}\sqrt[3]{\frac{E_p}{M_r}}\right)^2}}+\frac{\left[1-\frac{1}{\sqrt{1+\left(\frac{D}{a}\right)^2}}\right]}{E_p}\right]$$

15

Determine SN_{eff}

$$SN_{eff} = 0.0045D\sqrt[3]{E_p}$$

- D = depth of pavement above subgrade
- Ep = composite pavement modulus

16

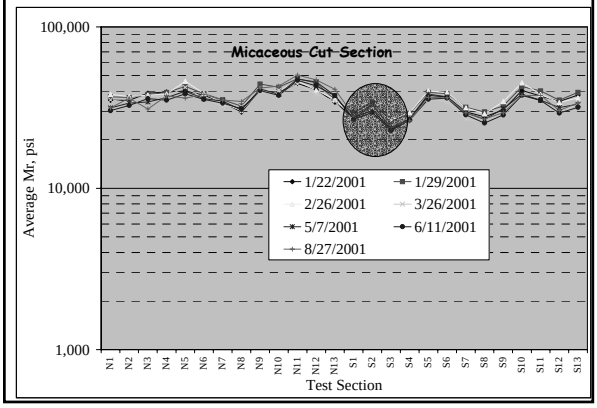
a_1* Determination

Control Section	Unknown Section
a_1, D_1	a_1*, D_1*
a_2, D_2	a_2, D_2
Subgrade	Subgrade
$SN = a_1D_1+a_2D_2$	$SN^* = a_1^*D_1^*+a_2D_2$

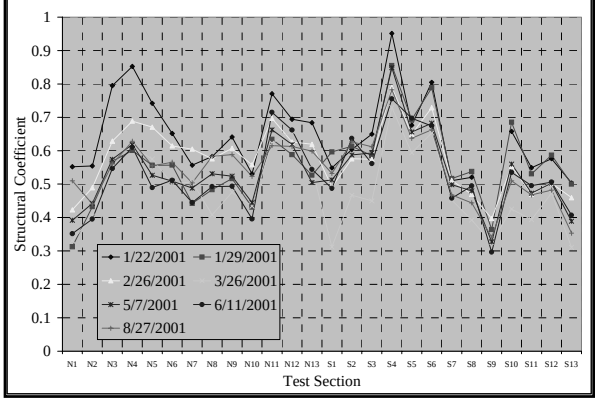
$$a_1^* = \frac{SN^* - SN + a_1D_1}{D_1}$$

17

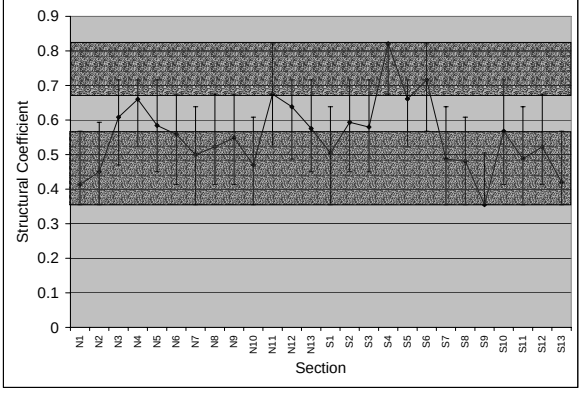
Roadbed Modulus



Structural Coefficients



Consideration of Variability



Summary Statistics (S7 as Reference)

- Average Value = 0.55
- Range of Values = 0.34 – 0.82

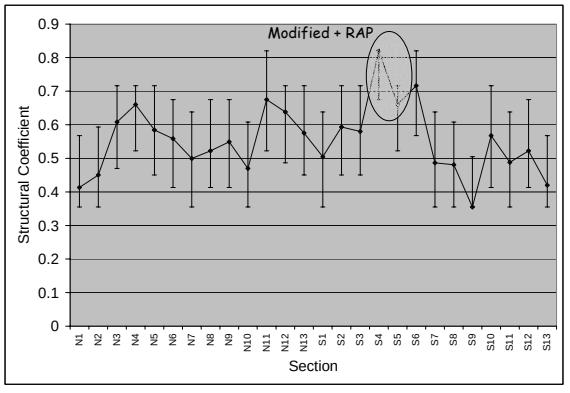
21

Factors to Investigate

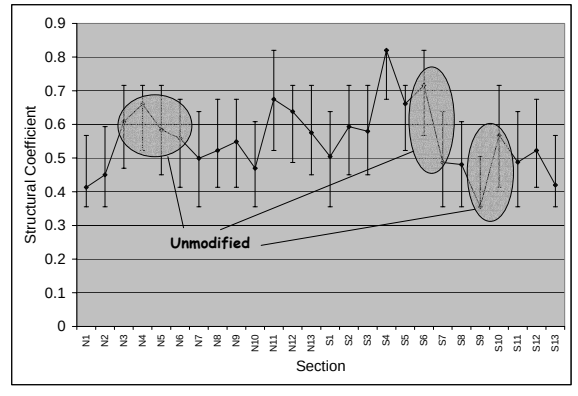
- Asphalt Content
- Binder Grade
- Binder Modification
- Mix Design
- Field Density
- Aggregate Type
- Aggregate Gradation

22

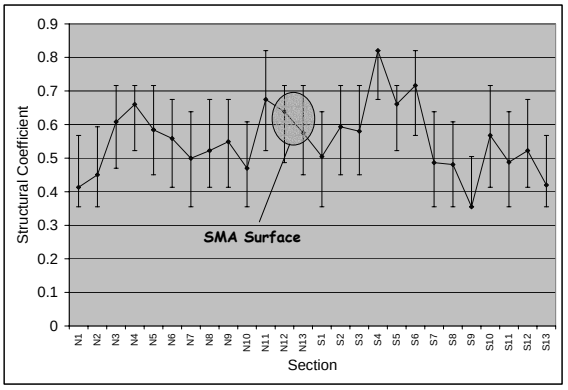
Use of RAP + SBS Modifier



Unmodified Mixes vs Modified Mixes



SMA Surface Course



Example Statistical Evaluation

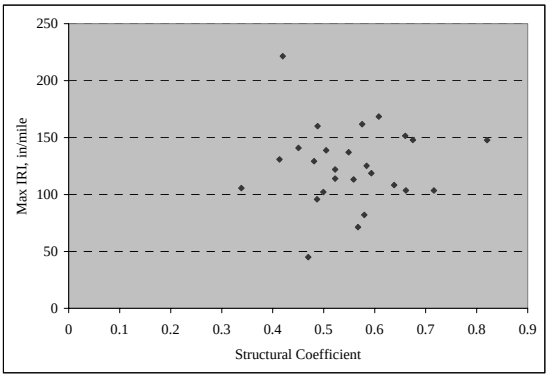
a = - 2.08 - 0.00143 Failure Grade + 0.013 ACRICH
- 0.00010 P4 + 0.0108 P16 + 0.0405 P200
+ 2.17 Section Compaction + 0.0253 AGG TYPE

R^2 = .311

Where:
Failure Grade = PG Performance Grade
ACRICH = optimum + 0.5%
P4, P16, P200 = %Passing Respective Sieves
Section Compaction = As-built % max density
AGG Type = 1 (limestone), 2 (slag/limestone), 3 (gravel)
4 (granite), 5 (Marble/Schist),
6 (Limestone/RAP)

26

Comparison to Performance



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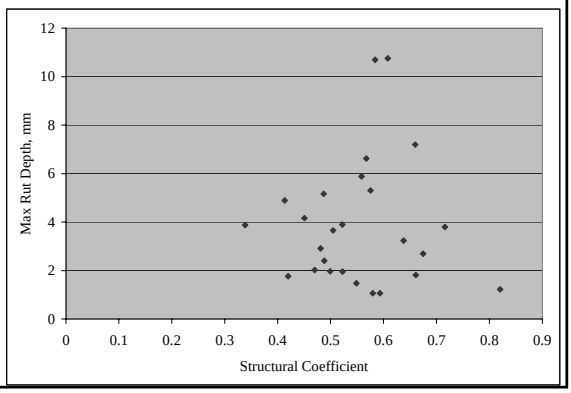

Conclusions

- Unable to clearly distinguish mix types by structural coefficient
- Using 0.44 is a reasonable value for most mixes
- Need for mechanistic characterization

29

Questions?